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2-(Imidazol-1-yl)-4-methylphenol

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The title compound, $C_{10}H_{10}N_2O$, was synthesized to investigate the structure of the Tyr–His residue in the active site of cytochrome c oxidase (CcO). The dihedral angle between the cresol and imidazole moieties is 42.21 (4)°, which is similar to that of the tyrosine-linked histidine in bovine heart CcO. In the title compound, the *R* and *S* enantiomers of axial chirality are connected by an O—H···N hydrogen bond.

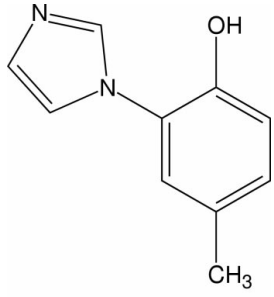
Key indicators

Single-crystal X-ray study
T = 123 K
Mean σ(C–C) = 0.001 Å
R factor = 0.049
wR factor = 0.157
Data-to-parameter ratio = 22.7

For details of how these key indicators were automatically derived from the article, see http://journals.iucr.org/e.

Comment

The title compound, (I), is considered to be a partial structure of the Tyr–His residue, a characteristic ligand to Cu_B found in the oxygen metabolic site of bovine heart cytochrome c oxidase (CcO, PDB ID 1OCO), determined by Yoshikawa *et al.* (1998). This covalent bond between His and Tyr has not been observed in the previous reports of the same enzyme (Tsukihara *et al.*, 1995) and bacterial CcOs (Iwata *et al.*, 1995). This structure is believed to arise from the coupling between a histidinyl moiety (His240 for bovine heart CcO) and the tyrosyl moiety (Tyr241) during the catalytic oxygen metabolism.



(I)

The dihedral angle between the least-squares planes of the phenolic and imidazolyl rings is 42.21 (4)° (Fig. 1). The N1—C4 bond length is 1.427 (1) Å (Table 1). The corresponding bond in fully oxidized CcO is 1.357 Å (Yoshikawa *et al.*, 1998). The O1—C5 bond length is 1.352 (1) Å, which is the same as that of the corresponding bond in CcO within the experimental error. The torsion angle C1—N1—C4—C5 is −42.3 (1)° in (I), the absolute value of which is slightly smaller than in CcO.

In the crystal, two enantiomers with axial chirality overlap each other in an antiparallel fashion (Fig. 2). There is an intermolecular hydrogen bond between the *R* and *S* enantiomers (Table 2).

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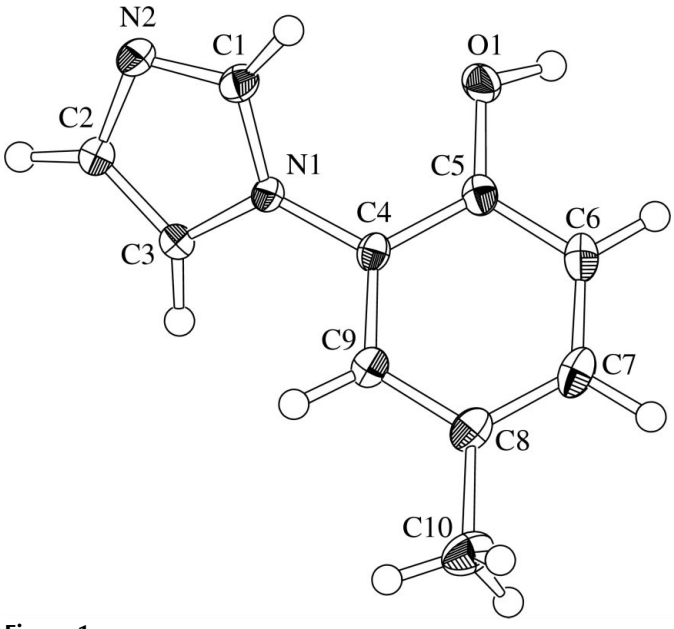

Figure 1
*ORTEP*II (Johnson, 1976) drawing of (I), showing the atom-numbering scheme. Displacement ellipsoids are drawn at the 50% probability level.

Experimental

The title compound, (I), was synthesized in two steps by an improvement of the reported method of Strehlke (1979). 2-Bromo-4-methylphenol (25.0 g, 0.13 mol) and K_2CO_3 (20 g, 0.14 mol) were suspended in dry acetone (300 ml). To the solution was carefully added chloromethyl methyl ether (20 ml, 0.25 mol) over several minutes. The mixture was stirred overnight. The resulting mixture was filtered off and washed with acetone several times. After concentration of the filtrate, the colourless oil was purified by distillation (b.p. 393 K at 0.20 Torr) to give 3-bromo-4-methoxymethoxytoluene (28.7 g) in 96% yield. A mixture of imidazole (500 mg, 7.34 mmol), 3-bromo-4-methoxymethoxytoluene (1.0 g, 5.35 mmol), copper powder (60 mg, 0.94 mmol) and K_2CO_3 (800 mg, 5.79 mmol) was stirred at 353 K for 1 h. The resulting mixture was cooled to room temperature and was poured into aqueous hydrochloric acid at pH 1. The mixture was extracted with water several times. The pH value of the combined aqueous layer was adjusted to be higher than 12 by the addition of aqueous KOH. The basic aqueous solution was extracted with chloroform several times. The combined organic layer was evaporated, and the residue was further dried *in vacuo*. The resulting oil was purified by alumina column chromatography. Crystals of (I) (670 mg, 72%) were obtained by slow evaporation of a chloroform solution. UV-vis and ^{1}H NMR spectra, and melting point (m.p. 445.5–447.0 K) of (I) were the same as those reported (*cf.* m.p. 445–447 K; Strehlke, 1979). HRMS (FAB, NBA), found: m/z 329.1265; calculated for $C_{10}H_{10}N_2O$: $M + 1$, 329.1290.

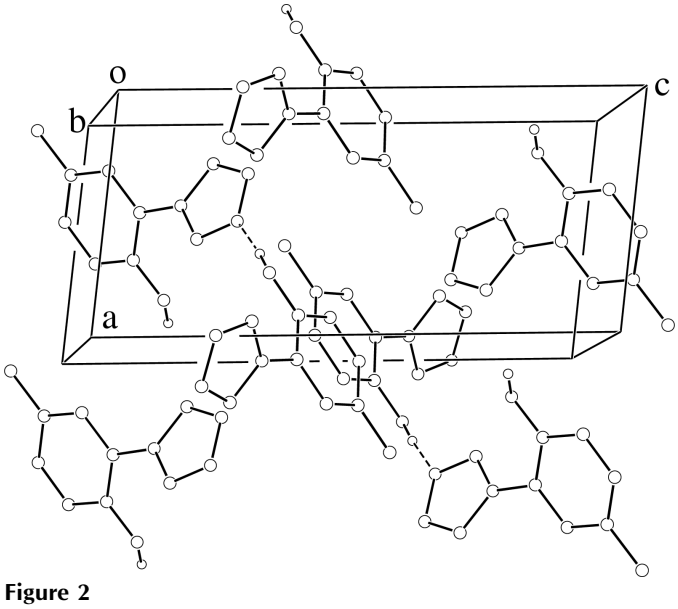

Figure 2
Crystal packing of (I). Hydrogen bonds are shown by dotted lines.

Crystal data

$C_{10}H_{10}N_2O$	D_x = 1.300 Mg m^{-3}
M_r = 174.20	Mo $K\alpha$ radiation
Monoclinic, $P2_1/n$	Cell parameters from 4184 reflections
a = 6.3521 (7) Å	θ = 2.5–30.5°
b = 10.4406 (6) Å	μ = 0.09 mm^{-1}
c = 13.523 (1) Å	T = 123.2 K
β = 97.199 (4)°	Prism, colourless
V = 889.8 (1) Å^3	0.34 × 0.24 × 0.10 mm
Z = 4	

Data collection

Rigaku R-AXIS–RAPID Imaging Plate diffractometer	R_{int} = 0.029
ω scans	θ_{max} = 30.5°
10 607 measured reflections	$h = -9 \rightarrow 9$
2704 independent reflections	$k = -14 \rightarrow 14$
2439 reflections with $I > 2\sigma(I)$	$l = -19 \rightarrow 17$

Refinement

Refinement on F^2	$w = 1/[\sigma^2(F_o^2) + (0.06P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
$R[F^2 > 2\sigma(F^2)]$ = 0.049	$(\Delta/\sigma)_{max}$ = 0.001
$wR(F^2)$ = 0.157	$\Delta\rho_{max}$ = 0.38 e Å^{-3}
S = 1.60	$\Delta\rho_{min}$ = −0.36 e Å^{-3}
2704 reflections	Extinction correction: Zachariasen (1967) type 2, Gaussian isotropic
119 parameters	Extinction coefficient: 0.16 (2)
H-atom parameters not refined	

Table 1
Selected geometric parameters (Å, °).

O1—C5	1.352 (1)	N1—C4	1.427 (1)
C1—N1—C4—C5	−42.3 (1)	C3—N1—C4—C5	134.97 (9)
C1—N1—C4—C9	141.42 (9)	C3—N1—C4—C9	−41.3 (1)

Table 2
Hydrogen-bonding geometry (Å, °).

D—H···A	D—H	H···A	D···A	D—H···A
O1—H1o···N2^{i}	0.97	1.66	2.629 (1)	174

Symmetry code: (i) $-\frac{1}{2}-x, \frac{1}{2}+y, \frac{1}{2}-z$.

All H atoms were found by difference Fourier syntheses and placed in suitable positions.

Data collection: *PROCESS-AUTO* (Molecular Structure Corporation, 1996); data reduction: *TEXSAN* (Molecular Structure Corporation, 1999); program(s) used to solve structure: *SIR*88 (Burla *et al.*, 1989); program(s) used to refine structure: *TEXSAN*; molecular

graphics: *ORTEP*II (Johnson, 1976); software used to prepare material for publication: *TEXSAN*.

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